

is not of critical importance, since the transmission of acoustic energy through the relatively soft adhesive is much less efficient than the transmission through the metal foil 195.

[0058] Alternatively, the slots 205 can be dimensioned and completely filled with epoxy or some other material with a low acoustic velocity, so that the acoustic energy coupled between the transducer 180 and the substrate 120 through the slots 205 is 180 degrees out-of-phase with the acoustic energy coupled between the transducer 180 and the substrate 120 through the tines 200. In this manner, the excitation of the desired waves on the substrate surface from this “parasitic” acoustic energy traveling through the slots 205 will constructively add to the acoustic energy diffracted by the tines 200. In order to provide this effect, the metal foil 195 may have to be made thicker in order to adjust the relative phase of the acoustic energy traveling through the slots 205.

[0059] FIG. 9 illustrates a grating 185b that comprises a metal block 210, e.g., aluminum, on which a grating pattern is hot stamped or coined to form alternating ridges 215 (perturbation elements) and grooves 220. After the coining process is completed, the metal block 210 is then adhered to the underside of the transducer 180 using a suitable adhesive, such as epoxy. The resulting subassembly (transducer 180 and metal block 210) is then suitably adhered to the front surface 135 of the substrate 120. Again, the cured cement layers should be no more than 0.025 mm thick, so that the elasticity of the grating 185 is not unduly increased. The metal block 210 is preferably one-half wavelength thick (which in aluminum, is 0.57 mm at 5.53 MHz), so that the acoustic energy is transferred between the transducer 180 and substrate 120 without changing impedances. If acoustic impedance matching is desired between unequal acoustic impedances of the transducer 180 and substrate 120, the thickness of the metal block 210 can be adjusted to achieve the desired impedance matching.

[0060] FIG. 10 illustrates a grating 185c that is formed by depositing a material such as glass frit (e.g., a lead-oxide containing ceramic) on the front substrate surface 135 in accordance with a grating pattern to form alternating ridges 225 and grooves 230. If needed, the substrate surface 135 may then be suitably processed to harden the grating material. The ridges 225 of the grating may then be partially ground down to ensure that all of the ridges 225 have an equal and proper height. The transducer 180 is then adhered to the flattened ridges 225 using a suitable adhesive, such as epoxy. As an alternative to ceramic material such as glass frit, the grating pattern can be printed on the front substrate surface 135 using a polymer ink. As illustrated in FIG. 11, a grating 185d can alternatively be formed by depositing glass frit or polymer ink on the bottom surface of the transducer 180 to form alternating ridges 235 and grooves 240.

[0061] FIG. 12 illustrates a grating 185e that is formed on the front substrate surface 135 to form alternating ridges 245 and grooves 250. The grooves 250 can be formed using any suitable means, e.g., chemical etching, grinding, sandblasting, laser ablation, etc. The transducer 180 is then adhered to the grooved substrate surface 135 using a suitable adhesive, such as epoxy. In bonding the transducer 180 to the substrate, it is desirable to avoid filling the grooves with the adhesive. If such filling cannot be avoided, the grooves 250

are preferably made deep enough to render the acoustic coupling between the adhesive and the transducer 180 negligible. That is, the increased depth of the grooves 250 will accordingly increase the thickness of, and thus the compressibility, of the entranced adhesive. Optionally, the size and depth of the grooves 250 can be designed, such that the acoustic energy traveling through the adhesive is 180 degrees out-of-phase with the acoustic energy traveling through the ridges 245. As illustrated in FIG. 13, a grating 185f can alternatively be formed in the bottom surface of the transducer 180 to form alternating ridges 255 and 260.

[0062] Although particular embodiments of the present invention have been shown and described, it should be understood that the above discussion is not intended to limit the present invention to these embodiments. It will be obvious to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the present invention. Thus, the present invention is intended to cover alternatives, modifications, and equivalents that may fall within the spirit and scope of the present invention as defined by the claims.

What is claimed is:

1. A touch sensor, comprising:

an acoustic substrate having a surface;

an acoustic transducer; and

an acoustically diffractive grating disposed between the substrate and the transducer, the diffractive grating coupling acoustic energy within the acoustic transducer to an acoustic wave propagating along the surface of the substrate.

2. The touch sensor of claim 1, wherein the diffractive grating comprises an array of parallel elements.

3. The touch sensor of claim 2 wherein the elements have a pitch equal to the wavelength of the acoustic wave.

4. The touch sensor of claim 1, wherein the diffractive grating is structurally distinct from the transducer and substrate.

5. The touch sensor of claim 1, wherein the diffractive grating is structurally integrated with the substrate.

6. The touch sensor of claim 1, wherein the diffractive grating is structurally integrated with the transducer.

7. The touch sensor of claim 1, further comprising:

another acoustic transducer; and

another acoustically diffractive grating disposed between the substrate and the other transducer, the other diffractive grating coupling acoustic energy within the other acoustic transducer to the acoustic wave.

8. The touch sensor of claim 1, wherein the substrate surface is substantially flat.

9. The touch sensor of claim 1, wherein the transducer comprises a piezoelectric element.

10. The touch sensor of claim 1, wherein the diffractive grating comprises a deposited glass frit.

11. The touch sensor of claim 10, wherein the glass frit is screen printed.